PB82-126137

Visibility Benefits Assessment Guidebook, Executive Summary

Abt/West
Denver, CO

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Aug 81

U.S. Department of Commerce
National Technical Information Service
NTIS

PB82-126137

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/5-81-002
August 1981

Air

EPA

Executive Summary

Visibility Benefits Assessment Guidebook

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NATIONAL TECHNICAL
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U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/5-81-002	2.
3. RECIPIENT'S ACCESSION NO. PB82 126137	
4. TITLE AND SUBTITLE Executive Summary Visibility Benefits Assessment Guidebook	5. REPORT DATE August 1981 (Date of Preparation)
	6. PERFORMING ORGANIZATION CODE 310036
7. AUTHOR(S) Robert D. Rowe, Ph.D. Lauraine G. Chestnut	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Abt/West 1410 Grant Avenue Suite C-207 Denver, CO 80203	10. PROGRAM ELEMENT NO. B11A2A
	11. CONTRACT/GRANT NO. 68-02-3528
12. SPONSORING AGENCY NAME AND ADDRESS U. S. Environmental Protection Agency OAQPS, SASD, EAB, MDS RTP, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED Final
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Executive Summary is a companion volume to the Visibility Benefits Assessment Guidebook. Its purpose is to provide an overview of the major concepts and procedures covered by the guidebook. The Visibility Benefits Assessment Guidebook provides a comprehensive and critical assessment of visibility benefits analysis as it exists today. The Guidebook describes the relationship between atmospheric chemistry, visual perception, and theoretical and applied welfare economics and presents a description of the most promising methodologies for accomplishing benefits anlaysis. Case studies are also included.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
		13B

18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 36
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

EPA-450/5-81-002

Executive Summary

Visibility Benefits Assessment Guidebook

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August 1981

VISIBILITY BENEFITS ASSESSMENT GUIDEBOOK

EXECUTIVE SUMMARY

1.0 INTRODUCTION

Good visibility is something that people value in recreational, residential, and other situations. When vacationers make the drive to the Grand Canyon, they expect to have a good view of the canyon. Few people would be willing to spend the necessary time and money to go there if they knew that the canyon vistas would be entirely obscured by haze. For those who find the view partially obscured or the clarity of the view reduced, the value of the experience is diminished, although they may still choose to make the trip. Similarly, people prefer to have clear views from their homes. Whether households have open views from their home that may be obscured by haze or whether only the color and brightness of the sky is noticeable, reduced visibility affects people's moods and their enjoyment of their residences.

There are many reasons why people value and protect good visibility. Economists divide these reasons into three categories. The first is that people value good visibility when they are using a site such as a residence or a park—this is called activity or user value. If people know where they will live and vacation in the future, they will want to protect visibility in anticipation of future as well as present activity value. However, people usually experience some uncertainty planning future activities and may want to preserve a certain level of visibility in order to maintain the option of enjoying that site in the future—this is called option value. This may be a particularly important value when visibility deterioration is difficult to reverse. A third reason that

people may want to preserve visual quality is simply to know that it exists, though the individual does not ever intend to visit the site--this is called existence value. This value may be especially important with regard to unique natural wonders, such as the Grand Canyon, and may be tied to the philanthropic goal of preservation so that future generations will be able to enjoy the site. Changes in air quality that affect any of these values will be associated with changes in an individual's well-being.

Visibility is often reduced due to natural causes, such as fog, rain, and wind blown particles, but human activities have long been recognized as an important contribution to diminished visual aesthetics. For example, in response to recent EPA inquiries, Federal Land Managers have indicated that roughly one third of the mandatory Class I Federal areas* experience, at least at times, undesirable visibility conditions due to manmade pollution.

Reflecting the importance of protecting visual aesthetics from manmade pollution in our scenic areas, the 1977 Clean Air Act Amendments established a national goal of remedying existing and preventing future manmade visibility impairment in mandatory Class I Federal areas. They mandated the EPA to establish regulations to ensure that reasonable progress toward this goal would be made. The EPA report to Congress, Protecting Visibility, notes that the determination of what is reasonable progress toward the national goal requires that the value as well as the costs of protecting or improving visibility be considered.

*International parks, national wilderness areas, national memorial parks exceeding 5,000 acres, and national parks exceeding 6,000 acres.

Visibility regulations based upon the 1977 Clean Air Act Amendments were promulgated on December 2, 1980. They indicate that some visibility impairment will be tolerated only if the costs of reducing or preventing impairment are considered too high. However, the size of these costs is only relevant when compared to the benefits of the improved visibility to be gained from control, or lost from the lack of control. Therefore, in order to decide whether or not to tolerate existing or additional visibility impacts, some judgment regarding the size of the benefits must be made. Thus, techniques to determine the value of visibility would be an important aid in determining the appropriate level and type of pollution controls to be required.

Although the potential usefulness of estimates of the benefits of visibility aesthetics has long been recognized, aesthetic impacts of pollution have tended to be considered nonquantifiable. This is no longer the case. There are at present several defensible economic methodologies being applied and developed to estimate the value of changes in visual quality that may result from changes in air pollution control. Applications of these techniques—referred to as visibility benefit analyses—can be used to estimate the dollar value of changes in visibility. This can add to our knowledge of the benefits of pollution control and improve the benefit-cost analysis of controls. Current research indicates that in most cases the benefits of protecting visibility are substantial. This suggests that the benefits of visibility should be included in the benefit-cost analysis in order to help determine the appropriate allocation of resources.

The Visibility Benefits Assessment Guidebook aims to introduce visibility benefit analysis techniques that can be used to estimate benefits, in dollars, for changes in visibility aesthetics resulting from

alternative levels of air pollution control. Policy makers can then compare these benefit measures to the costs of controls. The Guidebook saves researchers or reviewers of visibility benefit analyses considerable time and effort in becoming well-versed by providing a comprehensive review of the theory, terms, and best practice techniques. The Guidebook discusses application of these techniques to evaluating existing or potential visibility impacts from single sources or regional haze in recreational, rural, or urban settings. Documentation of the assumptions, strengths, and limitations of each method provides inexperienced users with a technical basis for interpreting the results of visibility benefit studies. The results of ten case studies are presented to demonstrate the magnitude of pollution control benefits. In many cases, these benefit estimates may be used to establish initial estimates of damages for other sites. In short the guidebook translates technical work for a broad audience, provides information about experts in the area and data sources, and offers references on specific topics.

The guidebook is organized as follows:

Chapter 2. The conceptual economic framework and definitions of monetary benefit measures for visibility improvements derived from consumer utility theory and demand analysis.

Chapter 3. An overview of required inputs from other disciplines to aid the economic analyst in communicating with physical scientists, psychologists, and sociologists in performing a complete benefit analysis.

Chapter 4. The applications, theoretical foundations and strengths and weaknesses of economic techniques currently used to measure benefits of visibility and overall air quality changes. These techniques include bidding methods, property value studies, travel cost studies, the ranked attribute approach and others.

Chapter 5. A summary of the start to finish research tasks for a complete visibility benefit analysis with suggested step-by-step decision and application guidelines.

Chapter 6. Five case studies of actual applications for both of the two predominant techniques—bidding methods and the hedonic property value approach—and a comparison of their procedures and results.

A glossary, annotated bibliography, and an appendix with sample picture sets and questionnaires for the bidding method are also included.

2.0 CONCEPTS AND MEASURES OF ECONOMIC BENEFITS

Performing a benefit analysis of changes in visibility aesthetics first requires a careful definition of what the benefits are and how monetary measures of these benefits are defined. This is especially important for visibility aesthetics, because the concepts of visibility as an economic good and of monetary benefits from visibility improvements may not be obvious. Therefore, before launching into a description of the actual benefit estimation techniques, it will be helpful to present the general definition of benefits that economists use and that the estimation techniques attempt to capture.

Consumer demand theory provides a framework for analyzing changes in an individual's well-being caused by changes in visual quality and for defining measures of benefits of these changes. The theory asserts that individuals derive well-being, or what economists call utility, from the consumption of goods and services. Thus, any change in the level of consumption that affects someone's utility, such as a change in visibility at a favorite park, has a value. This change in utility may be either a benefit or a damage, depending upon whether the individual's well-being is enhanced or diminished. The appropriate monetary measure of benefits for an improvement in visibility indicates how much the increase in utility is

worth. The benefit measure therefore equals the change in income that would yield the same change in utility as that caused by the improvement in visibility.

Market goods have easily recognized value because when individuals purchase them they forego purchasing other goods and services that could also have increased their well-being. The market price an individual pays for a good therefore represents a minimum monetary measure of value to the individual. Visual quality also has value even though it is not purchased or sold in a market. People change their recreation patterns, move their residences, or simply alter their moods due to changes in the existing level of visual quality. Thus, analyzing how individuals react to visual quality changes may reveal the value they place on these changes in visual quality. In other words, a visibility benefit analysis attempts to determine what individuals would be willing to pay for a change in visual quality if it were possible to purchase it.

In order to determine the value or benefits of changes in visibility, economists usually try to estimate or derive a demand curve for visual quality. Three related monetary measures of value are used in visibility benefit analysis, and can be derived from demand curves. They are willingness to pay (WTP), expenditures, and consumer surplus. To illustrate these measures, a demand curve for an ordinary market good is given in Figure A and a demand curve for visibility is given in Figure B.

WTP is the maximum amount an individual would be willing to pay in order to obtain a given amount of a good or to experience a given level of visibility. The maximum WTP for an additional unit is the corresponding point on the demand curve—B for quantity F and C for quantity G in both

Figures A and B. Expenditures represent the actual amount a consumer spends, which in a situation of free choice would never be more than his maximum WTP. Expenditures are represented by the price of each unit times the quantity of units—the area BDFO for quantity F and a constant price B in Figure A. Although consumers do spend money in order to go to a park that has clear visibility or to live in a neighborhood that has clean air, consumers do not directly purchase visibility. Therefore there are no expenditures for visibility in Figure B.

In both of the illustrated cases, the consumer is paying less than his maximum WTP for all units. This surplus value, or the difference between the maximum WTP and expenditures, is called consumer surplus. Consumer surplus equals the difference between expenditures, if any, and the area under the demand curve up to the quantity of the good consumed or the quantity of visibility experienced—the area ADB at price B and quantity F in Figure A and the area ADFO at quantity F in Figure B.

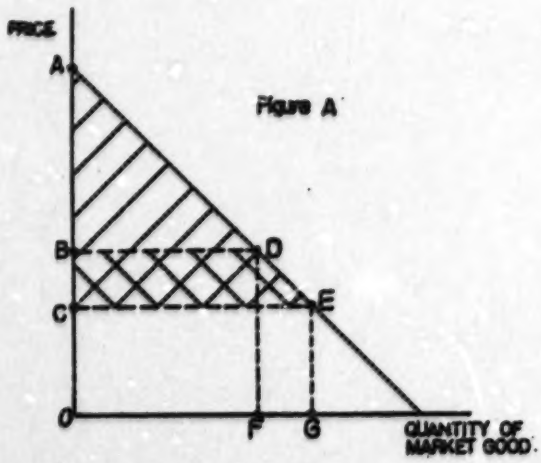

Figure A

Demand for Market Good

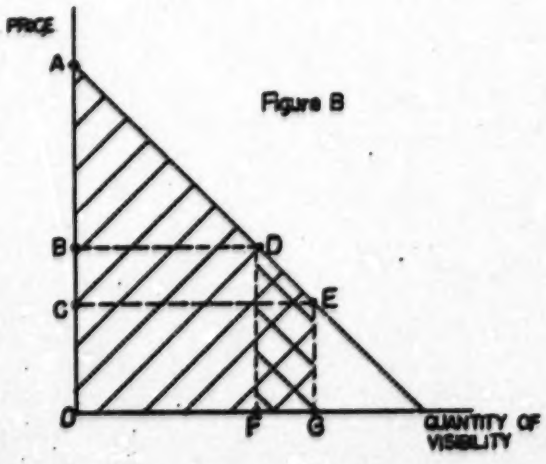

Figure B

Demand for Visibility

For changes in prices or quantities of goods, the changes in consumer surplus are also shown. If the price of a market good falls from B to C, the increase in consumer surplus is shown by the area BDEC in Figure A. If the quantity of visibility increases from F to G, the increase in consumer surplus is the area DEGF in Figure B.

The change in consumer surplus that results from a change in visibility is the measure of the change in an individual's well-being (benefits or damages) caused by the visibility change. When the level of visual quality changes it affects the individual's willingness to pay for visual quality or for the associated activity or good that has been affected. If visibility is improved, for example, the individual would be willing to pay more for either the higher visibility directly or for the activity or good that is enhanced by the improvement in visibility. The change in utility caused by the improvement in visual quality is reflected by the change in WTP. However, in some circumstances, the individual will have to pay part or all of his increased WTP in order to obtain the improvement. Such an increase in expenditures would leave less income left to purchase other goods and services; thus, to the extent that expenditures to obtain or enjoy visibility are increased, the increase in utility from having improved visual quality is partially offset by decreased utility from other goods and services. Therefore, it is only the change in consumer surplus that represents the net benefit to the individual resulting from the change in visibility.

In general, the change in consumer surplus tells us how much of an increase in money income would have caused the same net increase in utility as that caused by the visibility improvement. Thus, the aim of any

visibility benefit analysis is to estimate the changes in consumer surplus that would occur in the particular circumstances under study. By aggregating the changes in consumer surplus for the individuals across all affected individuals, benefit measures reflecting the total change in utility can be obtained for use in benefit-cost analysis.

There are four refined measures of consumer surplus that each have slightly different interpretations. Each of these refined measures is a theoretically correct measure of benefits, but under different circumstances. In practice they are often quite close in size and therefore the distinctions are sometimes ignored. Sometimes more than one of these measures may be applicable in a given study situation and therefore several are estimated. These refined measures are defined and discussed in the Guidebook. The important point is that they are measures of changes in well-being and as such are used as estimates of economic benefits that result from changes in visual quality.

3.0 TECHNIQUES FOR ESTIMATING BENEFITS

The techniques used to obtain measures of the value of visual aesthetics rely upon one of two categories of approaches: 1) asking people to establish values directly through the use of hypothetical, or what is known as contingent market, situations posed to survey respondents; and 2) using actual market data regarding the relationship between private markets and visual quality, combined with special analytical methods, to infer implicit prices and the demand for visual quality.

The first group, contingent market approaches, elicits the value of visual quality through surveys of how respondents think they would behave if a proposed visibility change were to occur under various hypothetical

circumstances. The usual version of this approach is the bidding method. By this technique respondents are asked to estimate their willingness to pay (in terms of entrance fees, utility bills, or whatever payment mechanism is applicable to the situation) to achieve or prevent a given change in visual quality that is described or pictured for them. Another contingent market approach is a variation on the travel cost method: respondents are asked how they would change their travel plans if they knew that visibility at a particular recreation area were to change.

The second group, actual market approaches, uses market data in cases where the selection of a market good may vary with visual quality. Residential property value studies are a common application of this approach. Such studies attempt to derive the demand for visual quality by determining the effect of different levels of visual quality on the individual's willingness to pay for a residence.

Following are brief descriptions of each of the most frequently applied, or most promising, contingent market and actual market techniques for estimating benefits for changes in visibility aesthetics. Following these descriptions is a discussion of the necessary considerations in choosing an estimation technique.

Contingent Market Techniques

In bidding methods, respondents are given information on current and proposed or potential future levels of visual quality at a particular site. They are also given hypothetical markets that describe how payments for changes in visual quality are to be made or received by the respondents. They are then asked to bid their maximum willingness to pay (WTP) or minimum willingness to accept compensation (WTA) to obtain or prevent the change.

If a degradation of visibility is predicted, respondents might be asked their WTP to prevent this change or their WTA to allow the change. Similarly, for a proposed visibility improvement, respondents are asked their WTP to fund the change or their WTA to forego the change. For example, respondents might be presented a hypothetical situation--"Local air quality may be degraded by energy development from the current level, depicted in picture A, to a lower level, depicted in picture B" (illustrated with photographs)--and a market mechanism--"If a surcharge were to be added to your utility bill that would go to fund equipment that would prevent visibility degradation, what is the maximum you are willing to pay each month on your utility bill to prevent the degradation in visibility from level A to level B?" Answers are usually elicited by asking the respondent if he would be willing to pay or accept a given amount. The amount is adjusted until the highest amount the respondent would be willing to pay or the lowest amount he would be willing to accept is determined. This amount can be used as a direct estimate of the change in the individual's consumer surplus that will result from the projected change in visual quality.

Aggregate benefits are determined by projecting the average bids for the respondents across all individuals that would be affected by the visual quality change. The results must be adjusted for differences between the respondents and the total impacted population in income and other characteristics. If benefits will continue over a substantial period of time, future benefits are usually discounted using standard procedures.

It is imperative that this approach be carefully designed and monitored, because the valuations given by respondents may vary with small

nuances in its application. The values that respondents report may well reflect their "true" values, estimated with a great deal of uncertainty, but the respondents are subject to the influences inherent in the design of the survey. These influences may decrease the accuracy of the responses and may cause biases in the valuation process. Most important, the contingent market mechanism and the proposed air quality changes must seem realistic and credible to respondents. Otherwise, the hypothetical questions will not elicit accurate answers from respondents (hypothetical bias). Tests for the occurrence of bidding method problems and actions to minimize their impacts on the accuracy of the valuation process have been and are being refined. The evidence to date is that if hypothetical problems can be overcome, the other potential biases may also be eliminated.

Bidding methods, and other contingent market approaches, also require that the change in visual quality to be valued be accurately communicated to the respondent. Pictorial representations of alternative visual quality scenarios using photographs, slides, and motion pictures, coupled with verbal descriptions and maps, have become the standard mechanism for displaying alternative scenarios of visual quality. To be successful, the scenario development must be clearly understood, realistic, uniform for all respondents and, hopefully, leave the respondent with a feeling that the situation and his responses are not only credible but important. In addition, it must be possible to link the visibility scenarios as described to the respondents to the costs of attaining or avoiding the associated levels of pollution. This requires knowing the nature and the sources of the pollutants that are affecting the study area as well as knowing how people perceive the effects of the pollutants. A competent application therefore necessitates interaction with other physical and social scientists.

The contingent travel cost approaches to determining the value of visibility at a recreation site follow the travel cost literature by recognizing that to use the services of a recreation site, users not only incur the expenses of entry fees and equipment, but must get to the site. The cost, or price, to an individual of using the services at a recreation site will vary according to the travel time and expenses incurred getting there. The user's willingness to incur these expenses will be affected by changes in the characteristics of the site, such as visibility. The travel cost approaches attempt to determine the willingness to pay for the quality of the recreation experience by examining the changes in travel costs various individuals are willing to incur in order to use various sites as air quality changes.

Travel cost approaches have been applied extensively to estimate the demand for recreation sites using readily available data on visitation rates, travel distances, and visitor characteristics such as income. However, estimating the demand for a particular characteristic of recreation sites, including visibility conditions, requires data that are less readily available, and generally requires accounting for all other important characteristics of the sites as well.

Such applications of the travel cost approach are still being developed. The contingent travel cost approach is a promising variation. Sufficiently detailed data are obtained by surveying recreation site users as to their expected recreation travel behavior given alternative hypothetical scenarios of environmental conditions both at the site and at competing sites. A utility maximizing individual is assumed to recreate at the nearest outdoor facility if all areas are equal and to recreate at the next nearest area only if there is significant deterioration at the closest

site. By using answers to detailed questions on expected activity rates at selected locations, given various site attributes, coupled with the costs of substituting activities across locations the value of changes in the levels of visibility can be inferred.

Other contingent market approaches that are less well developed for estimating benefits for changes in visual quality than those so far described, but that may prove to be useful, include the household production function approach and ranked attributes. The household production function approach is somewhat similar to the travel cost approaches in that changes in activities and expenditures that are influenced by air quality are used to generate WTP curves and damage functions for changes in air quality. In the ranked attributes approaches, survey respondents are asked to rank order sites that have different levels of visual quality, prices and other site attributes. The respondent does not put a dollar value on visual quality but values are revealed indirectly by the rankings or probabilities that a site will be chosen for recreation, given the different entrance fees, travel expenditures, and other costs associated with using each site.

Actual Market Approaches

Property value studies are based on the supposition that if air quality varies across the area and if people are willing to pay more for a residence with better air quality, the amount they are willing to pay will be revealed by the price differences between properties that are similar in all respects except air quality. Most such studies have used the hedonic price technique to estimate an implicit price for changes in air quality that are associated with, and influence, the value of residential property.

Hedonic price theory suggests that the household values a residential property because it embodies particular attributes that the household desires, such as places to sleep and eat, a pleasant environment, and access to employment and recreation. The amounts of each attribute determine the price that consumers are willing to pay for the residence. If these attributes can be defined and quantified by consistent units of measure, then by observing the prices of homes with different levels of each attribute, the effect of each attribute on the prices of homes can be determined.

This relationship between the price of a home and its attributes is called a hedonic, or implicit, price function. Its estimation is the first step of the hedonic price technique. The hedonic price function enables the analyst to statistically hold constant all attributes but one in order to see how changes in the level of that attribute alone affect the prices of homes. The hedonic price function can be used to determine how differences in visibility would affect prices of residential property if each residence were identical in every other respect.

In this way, a marginal implicit price for each attribute can be derived from the hedonic price function. The marginal implicit price of an attribute is the additional amount that must be paid in order to obtain a home with an additional unit of the attribute. Deriving a marginal implicit price for changes in visual quality is a first step toward estimating the household's willingness to pay for changes in visual quality.

The next step requires observation of how the marginal implicit price for visual quality changes as the level of visual quality changes either across locations or across time. Thus, a WTP function is estimated which relates the marginal implicit price of visual quality to the level of

visual quality at which the household chooses to locate. It must also account for the effects of household income, household size, and other household characteristics and property attributes that influence the household's willingness to pay for visual quality.

Once estimated, the WTP function for visual quality can be used to derive total benefits for all households that are expected to be affected. Total benefits are the amount that all households are willing to pay for the improvement. If separate WTP functions are estimated for different household groups (separated according to income, location, or some other characteristic), the benefits for each group must be summed to obtain total benefits and some decision must be made concerning how to weight each group's WTP. Standard discounting procedures would be applied to aggregate benefits across time.

To conduct a property value study, fairly detailed residential property and household data must be available. In particular, air quality measures that reflect the aspects of air quality that people value and that are specific to each neighborhood must be available. This typically limits the locations and types of impacts that property value studies can consider. To date, property value studies have used average concentrations of specific pollutants or pollution indexes, such as the Pollution Standards Index (PSI), which are available in most urban areas, as proxies for air quality in each neighborhood.

Another actual market approach that has been applied with some success is the wage and salary approach. In this approach, willingness to pay for air quality is derived from differences in wages and salaries between locations with different air quality. In order to isolate the effects of air quality on wages and salaries, other influences must also be accounted for.

Choice of Benefit Estimation Technique

Before a complete benefit estimation study using any of these methods is undertaken, it would be desirable to determine if results from previous studies are sufficient to answer the questions currently under study. Two levels of accuracy are possible in transferring results. It may be possible to transfer actual or systematically adjusted results from past studies to achieve reasonably precise benefit estimates for the current study—a level of accuracy we call strong transferability. This requires that the circumstances of the two studies be identical or different in ways for which the effect upon benefit measures is well known. If this is not the case, it may still be possible to use previous results to set upper or lower bounds on benefit estimates for the current study as a starting point for decision making—a level of accuracy we call weak transferability. This requires that the direction, but not the size, of the differences in the situations be known. Theoretically, conditions are established which should ensure valid strong and weak transferability of results. Whether these conditions are met is an empirical question that must be answered for each study area under consideration. At present, only a few visibility benefit analysis studies have been completed from which to transfer results.

Which benefit analysis technique is appropriate for the study question at hand must be decided on a case-by-case basis. It will depend on the location and nature of the visibility impacts, data availability, and the budget and time available for the study. In general, contingent market approaches are much more flexible in terms of locations and types of impacts that can be considered, because survey questions can be designed to suit the particular circumstances under study. Actual market approaches

must rely on data that are already available. This implies that for many recreation and rural study areas, there may be no choice but to use a contingent market approach. Actual market approaches tend to be cheaper and quicker, however, because they do not necessitate any survey work, which can be very expensive and time consuming. No matter which approach is used, the researcher needs to be well aware of its strengths and weaknesses in order to conduct a credible analysis and in order to understand the meaning and reliability of the results.

The most important strengths of the bidding method are that it is well grounded in economic theory and flexible in application. The approach can be applied to obtain separate activity, option, and existence values, both on-site and at alternative locations. Any type and location of visual quality impact can be considered as long as the impact can be conveyed to respondents in a manner they can understand along with a credible contingent market mechanism. Similarly, the contingent travel cost approach is quite flexible, although it cannot be used to estimate option or existence values.

Contingent market approaches, however, presuppose that a particular change in visual quality can be described to respondents, usually with photographs and verbal descriptions, in a way that corresponds to what their perceptions of the actual experience would be. For example, it is assumed that a vacationer can look at a photograph of the Grand Canyon obscured by pollution and accurately predict how experiencing it in reality would lessen his enjoyment of the canyon and how it might cause him to alter his plans. These types of approaches also assume that individuals are capable of and willing to predict accurately their response behavior to a hypothetical situation that they may or may not have ever actually

experienced. In this respect, contingent travel cost methods may have an advantage over bidding methods because they ask questions about decisions that recreationists do routinely make.

An important strength of the property value approach and other actual market approaches is that they are based on households' or individuals' actual behavior. This is a significant advantage over bidding methods that ask people how much they would spend, but do not require them to part with their money. If the visual quality attribute is successfully separated from the other property attributes, the hedonic price technique can be used to determine how much households have actually spent to obtain various levels of visual quality.

Actual market approaches, however, presume that individuals respond in a predictable manner to visual quality conditions that they encounter in places where they live, work, and recreate. For example, it is hypothesized that individuals prefer to live in neighborhoods where the view is not impaired by air pollution. These approaches then assume that the intensity of such preferences is revealed by the individual's behavior and his willingness to pay for associated market goods.

A summary guide to method selection is presented in Table 1. In addition to these criteria, it is also important to consider that both contingent market and actual market approaches require several other analytical and operational assumptions upon which their validity depends. The analytical assumptions are similar to those used frequently in economic analysis. The operational assumptions concern the conditions necessary to ensure that the procedure is capturing the desired value. These assumptions need to be considered in any application of these valuation procedures. If they are not valid in theory or not met in practice, the validity of the results generated by the techniques are weakened.

Table 1

Selection of Visibility Benefit Estimation Method — A Summary[1]

Selection Criteria	Transfer Results of Previous Studies	Bidding Methods and Other Survey Approaches	Property Values and Other Market Approaches
Major strength	Lowest cost, quickest results	Flexibility in application to location, type of impact and values	Reliability of data reflecting actual behavior
Major weakness	Lack of prior studies and consistent empirical analysis	Reliability of data from hypothetical questions	Availability of data for nonurban locations and required variations in impacts
Cost and timing	Lowest cost, quickest results	Highest costs, often takes > 1 year, seasonal problems	Medium costs, usually < 1 year
Locations where impacts can be addressed	At present: weak transferability for urban areas and Southwest parks	All locations, Class I, urban, rural, other	Urban, or where sufficient data exists
Types of values	Constrained by prior studies, primarily activity values	Activity, option, existence	Activity, some option
Separability of impacts (health vs. aesthetics, etc.)	Constrained by prior studies, primarily not separated	Benefits are separable	Separability not yet addressed
Types of impacts that can be addressed	Constrained by prior studies	Haze or plume, and rates and levels of occurence; uniform or variable	Haze or plume, and rates and levels of occurence; must vary across study area
Evaluation of current vs. future impacts	Both, depending upon prior studies	May evaluate both current or future impacts	All alternative impact levels should occur in study area
Atmospheric data requirements	Accurate data required to match current situation to prior studies	Accurate data required for alternative "typical situations" across area	Accurate data required on all pollution levels at a neighborhood or census tract level
Economic and population data	Affected population characteristics	Affected population characteristics must be cross-checked with sample characteristics	Property values, property use and characteristics plus population characteristics
Reliability of data and results	Depends upon accuracy of prior studies and match to current impacts	Some uncertainty due to hypothetical approach	Reliable market data, some uncertainty regarding estimation techniques

[1] This table is to be used only as a summary of more detailed comparisons contained in Chapters 4 and 5 of this guidebook. The same criterion can be applied to travel costs, wage and salary hedonic techniques, etc., as they are developed for application to visibility benefit analysis.

4.0 OVERVIEW OF THE VISIBILITY BENEFIT ASSESSMENT

Visibility benefit analysis requires input from many fields in addition to economics in order to provide useful input for air pollution control policies. In general, it requires knowing or determining the following:

- Source of the pollution and its type, intensity, and frequency.
- Spatial dispersion of pollutants and type of impact (plume, haze).
- Scenic content of the affected view.
- Atmospheric conditions and transmission of visual images, which is affected by lighting, cloud cover, etc.
- Human perception of impacts.
- Psychological effects of perceived impacts.
- Economic valuations of impacts in terms of willingness to alter time or dollar expenditures.

The various research tasks necessary in a typical visibility benefit assessment can be organized into a six-step process. This process should not be considered a formal procedure, but merely a guideline to help the researcher understand the step-by-step process of performing a benefit analysis. There is at present no formal legislative requirement to perform visibility benefit assessments in any specific situations or in any particular format. In addition, any such guidelines should remain flexible enough to incorporate what is learned through more research and repeated application. The six basic steps are as follows:

Step 1: Problem Formulation

1. Describe potentially impacted area.
2. Identify sources of potential visibility changes.
3. Define potential pollution changes in terms of specific air quality measures.

4. Identify legal foundations and requirements relevant to pollution type, source and impact area.

5. Determine public perceptions of potential emission rates and air quality levels.

6. Determine if further analysis is required, i.e., screen out projects whose "worst case" impacts are obviously insignificant in terms of physical variables and human perceptions.

Step 2: Scenario Development

1. Determine existing air quality conditions in terms of appropriate air quality measures.

2. Determine the most probable future conditions without the proposed change, using selected air quality measures.

3. Define changes in visibility conditions expected to result from proposed action or policy, using selected measures.

4. Conduct initial physical impact analysis.

Step 3: Selecting the Economic Benefit Estimation Technique. Discern whether the results from previous studies can be transferred to the study at hand. If possible, using results from previous studies will save considerable time and money. If the results from other studies cannot be accurately or defensibly transferred, the benefit estimation technique(s) must be selected based upon the following factors:

1. The location of the impact—urban/rural/national park/other—and whether the impact is regional or site specific.

2. The nature of the impact. Take into consideration the timing of the impact; type of impact such as haze or plume; frequency, intensity and duration of the impact; and whether it is an aesthetic, health and/or materials impact.

3. Type of values (activity, option, existence) for which benefits are to be estimated.

4. Data requirements and data availability and reliability for each technique.

5. Necessary assumptions of each benefit estimation technique.

6. Costs and timing requirements for the study effort.

Step 4: Application of Estimation Technique. The bidding method and property value approach are the two most commonly used to date. If applying bidding methods, the following steps are necessary:

1. Determine the benefit measures (WTP, WTA) to be estimated.

2. Select alternative scenarios to be evaluated and select methodology for depicting visibility conditions, usually some type of pictorial representation.

3. Determine survey procedures—who will be interviewed and how and when they will be interviewed—and design survey instrument to obtain estimates of benefits with a minimum of respondents' time.

4. Pretest the survey and implement the survey.

5. Conduct statistical analysis and compute benefit measure estimates.

If applying the hedonic property value approach, the following steps are necessary:

1. Select final data—the most important of which are property and air pollution data—and make sure all neighborhood amenities are incorporated. Data may be available from U.S. Census, state and local government, or private organizations.

2. Select the study sample and organize data by adjusting data from different sources for compatibility.

3. Perform statistical analysis by estimating the hedonic price function, willingness to pay, and benefits or damages of the changes in air quality.

Step 5: Aggregation of Benefits Across All Affected Populations

Project benefit estimates for the study sample across the entire population expected to be affected. Adjustments should be made for differences in characteristics such as incomes. Benefits should be aggregated across the expected time frame of the impact using standard discounting procedures.

Step 6: Benefit-Cost Analysis

1. Identify related emission control costs.

2. Identify other environmental and non-environmental costs and benefits.

5.0 CASE STUDIES OF VISIBILITY BENEFIT ANALYSIS

The results of the dozen or more visibility benefit analyses conducted so far, including both contingent and actual market approaches, indicate overwhelmingly that the value people place on visibility aesthe-

tics is substantial. Protecting visibility aesthetics is therefore an important benefit of air pollution controls that should be considered in policy decisions. The results of the studies reviewed in the Guidebook are summarized below. Although the circumstances of each study differ, the results are broadly consistent, providing evidence that estimation procedures are valid.

The five bidding method studies reviewed in the Guidebook are the Four Corners study, by Randall et al. (1974); the Lake Powell study, by Brookshire et al. (1976); the Farmington study, by Rowe et al. (1980 a,b); the South Coast Air Basin study, by Brookshire et al. (1979; 1980); and the Grand Canyon/Southwest Parks study, by EPA (1981). Although the bidding method has been applied to several dozen other environmental and resource problems in recent years, these five are the best known applications to visibility benefit estimation. With the exception of the South Coast Air Basin study, all of these studies concern visual range and discoloration impacts upon recreation areas and local communities induced by rapid growth in the coal-fired electric-generating industry in the southwestern United States.

Each of these studies examines at least one alternative level of visual quality that occurs or is expected to occur in the study area. All of them have used pictorial presentations to describe visual quality variations to survey respondents. The scenario developments have evolved from general scenarios in the earlier studies, which defined air quality variations simply as "worst" to "best" and lumped several types of impacts together, to carefully defined scenarios in more recent studies that attempt to separate visibility aesthetics, power-plant siting, and health-related impacts and to distinguish between user values and existence

values. Only the Farmington study and the Grand Canyon/Southwest Parks study, however, have linked the visual quality scenarios to emissions, allowing the benefits of improved (or prevention of deterioration in) visual quality to be linked to the costs of attaining or preserving clean air.

All of the studies obtained a sufficient number of interviews for analysis, but not for all subgroups of respondents. In all cases the percentages of usable responses were high, but the percentages that refused to participate and the exact survey procedures were not generally reported. Self-selection bias may have occurred because respondents are likely to be different from those who refuse to participate, especially in terms of their concern about air quality. As studies have become more careful in defining impact scenarios and in isolating values for different types of impacts, questionnaire length has increased, creating the potential for response fatigue problems.

When bias tests were formally designed and implemented, bias problems were found in most cases. This has not always been the case for bidding method applications to other problems. In some cases the biases were not large, but the results indicate that respondents do have trouble putting quantitative values upon visibility and that they are influenced by the survey and questionnaire design.

In all of the studies, respondents' incomes have been found to be statistically correlated with respondents' bids, but the effect of incomes on bids appears to be surprisingly small. For residents, income elasticities (percentage change in bid divided by percentage change in income) are all less than one, and for recreationists they are very close to zero. This means that respondents with larger incomes are willing to pay somewhat, but not much, more than those with lower incomes.

The Four Corners study, conducted in 1972, was concerned with air and land (strip mining, transmission lines) visual aesthetic impacts of coal-fired electric generating plants on residents and recreationists in the Southwest. Respondents were shown photographs illustrating (A) the plant without pollution controls, and an unreclaimed strip mine; (B) the plant with some controls (circa 1972), and a partially reclaimed strip mine; and (C) the plant with no emissions, and no visible strip mining impacts. Residents said they would be willing to pay an average of $50 per year in additional sales taxes in order to obtain an improvement from A to B and an average of $82 to obtain an improvement from A to C.* Total regional WTP estimates were obtained by adding these results to the responses of recreationists concerning additional user fees they would be willing to pay. For A to B, the regional WTP was about $15.5 million per year, and for A to C, it was about $24.5 million per year.

The Lake Powell study, conducted in 1975, considered the visual impacts of large power plants and visible smoke plumes in view from a predominantly recreational site. Recreationists and a few local residents near Lake Powell were asked what they were willing to pay to prevent construction of an additional plant if only the plant would be visible and if the plant and pollution would be visible, as opposed to current conditions. Average bids by users of the recreation area, in terms of additional user fees per day, were between $.87 and $2.11 to prevent an additional plant and between $1.75 and $3.38 to prevent an additional plant and pollution. The lowest average bids were by residents while the highest average bids were by remote campers. Aggregate bids indicate that the

*All benefit figures in each case study are reported in dollars current the year the study was undertaken.

benefits of preventing visibility degradation at that site alone (there are also several other recreation areas in the vicinity) were $400,000 to $700,000 yearly.

The Farmington study, conducted in 1977, was also concerned with the impacts of coal-fired electric-generating in the Southwest. The focus of this study was the effects of reduced visibility upon local residents in and near Farmington, New Mexico. The three visibility levels illustrated by photographs of two standardized long distance landscape views from Farmington were (A) visual range of about 120 km, somewhat better than current conditions; (B) visual range of about 80 km; and (C) visual range of about 40 km. The average monthly bid by residents to prevent deterioration in visual range from 120 km to 80 km was $4.75, and to prevent deterioration from 120 km to 40 km was $6.50. Non-resident recreationists in the area had average bids of $3.00 and $4.00 in additional user fees per day for the same scenarios. Aggregate benefit estimates for the study area over a 35-year horizon, assuming a 10% discount rate, were $14.2 million for preventing A to B and $19.2 million for preventing A to C. One of the purposes of this study was to test for biases in the bidding process. Hypothetical, starting point, and information biases were detected. Additionally, it was found that in contradiction with theoretical expectations, WTA bids were much larger than WTP bids. This was attributed to differences in implied property rights in the two questionnaire procedures.

The South Coast Air Basin study, conducted in 1978, was an application of the bidding method and the property value approach to the same urban area in order to compare the results of these two techniques. The scenarios used in the bidding method were illustrated with photographs of

two views in Los Angeles showing (A) poor air quality as a visual range of about 2 miles, typical in much of the area; (B) fair air quality as a visual range of about 12 miles, the predominant condition in the area; and (c) good air quality as a visual range of about 28 miles. Residents in 12 different communities, each categorized as having poor, fair, or good air quality, were interviewed. Average monthly bids in communities with poor air quality were between $11 and $22 in order to obtain fair conditions. In communities with fair air quality, average monthly bids to obtain good conditions were between $5 and $28. In communities with good air quality, residents offered average bids of $18 to $67 per month to obtain good air quality in the entire region. For all proposed changes, aesthetic, acute health, and chronic health components each constituted about one third of the bid. Aggregate annual benefits of a 30% improvement in air quality for the region were estimated between $580 million and $650 million.

The Grand Canyon/Southwest Parks study, conducted in 1980, used interviews with urban residents at their homes in Los Angeles, Denver, Chicago and Albuquerque. The respondents were asked how much they were willing to pay to protect visibility at the Grand Canyon and at other parks in the Southwest region. Both users and non-users were interviewed in an attempt to derive both activity and existence values. Photograph sets depicted views from the Grand Canyon, Zion and Mesa Verde national parks, each with five levels of air quality. The middle level, C, represented typical current conditions. The expected impacts of uncontrolled emissions were shown in views A and B, and views D and E showed the expected impacts of more stringent controls than were currently in effect. The average user value bid in terms of additional daily entrance fees to improve air quality at the Grand Canyon from A to C was $2.76; and from A to E was $5.15.

An additional $4.29 per day was the average user value bid to prevent deterioration in regional air quality from C to B. The average preservation value bid, which the authors defined as user plus existence values, was $5.38 in terms of a residential monthly utility bill increment to prevent deterioration at the Grand Canyon from C to B, and was an additional $4.58 to prevent the same deterioration region wide. These results indicate the existence values overwhelm activity values, even for park users. Aggregate annual benefits for residents of the Southwest region were estimated to be $470 million for preserving visibility at the Grand Canyon and $889 million for preserving visibility in the entire region. Extrapolated to the nation as a whole, these annual benefit estimates were $3,370 million and $5,760 million respectively.

The magnitude of the preservation value bids from this study suggests that the scenarios should be evaluated in terms of their credibility to the respondents. Future attempts to obtain existence values need to be designed in order to test for hypothetical bias problems in the procedure.

The five property value studies reviewed in the Guidebook are the Washington D.C. study, by Nelson (1978); the Boston study, by Harrison and Rubinfeld (1978); the Denver study, by Bresnock (1980); the South Coast Air Basin study, by Brookshire et al. (1979; 1980); and the San Francisco Bay Area study, by Loehman et al. (1980). They are all based, at least in part, on the theoretical framework (described in Section 3.0) for applying the hedonic price technique to residential property values to estimate the WTP for air quality at the residential site. Each study was conducted in a major metropolitan area where substantial and detailed data regarding households, property, and air pollution were available.

All of these studies have applied the hedonic price theory in a similar way. However, there were some significant differences in the specification of the hedonic price function. Due to differences in housing markets and in data availability, different combinations of property characteristics (in addition to neighborhood air pollution measures) were used to explain property values. All of the studies derived marginal implicit prices for some measure of air pollution and estimated WTP for reductions in air pollution, as previously discussed.

One important characteristic of the property value studies conducted so far is that they have all used measures of air pollution, usually of a specific pollutant, in the hedonic price function. Because many common pollutants in urban areas have both aesthetic and health as well as some material damage effects, there has been no attempt in these studies to separate these impacts. We do not know from these studies, therefore, how much people are willing to pay to avoid simply the aesthetic impacts of air pollution. We know only what they are willing to pay to avoid the combined impacts.

In the Washington D.C. study, measures of TSP (total suspended particulates) and oxidant were used. Both measures were found to have a negative relationship with property values. Based on 1970 data, the estimated mean marginal implicit price of TSP was $69 per μg/m3 (micrograms per cubic meter) and of oxidant was $15 per .001 ppm (parts per million). Total benefit estimates were not derived.

In Boston, based on 1970 data, the average property value differences attributable to air pollution between those neighborhoods with the highest levels of pollution and those within the standards, all other

things being equal, was about $5,000 to $6,500.* The reported mean marginal implicit price was $1,613 for a one pphm (parts per hundred million) change in NO_x. Both NO_x and TSP measures were used, but the results of the TSP equation were implausible and therefore the NO_x equation was used for further analysis. Using the estimated WTP functions, benefit measures for the reduction in emissions expected by 1990 from automobile emissions standards were derived. These averaged $83 per household per year.

The Denver study used 1977 data and measures of carbon monoxide (CO) concentrations, one of the pollutants in Denver that frequently exceeds national ambient air quality standards. The mean marginal implicit price was between $67 and $83 per one pptm (parts per ten million) CO. This price implies a property value difference of approximately $10,000 to $12,000 between those neighborhoods with the worst pollution levels and those that met the standards, all other things being equal. From the estimated WTP functions, the benefits of attaining national ambient air quality standards were estimated at an average of $258 per household per year.

The South Coast Air Basin study used 1978 data and measures of NO_2 and TSP. The benefit estimates derived using each measure were quite comparable to one another. The mean marginal implicit price was $2,010

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*These estimates of property value differences are ballpark figures given for illustrative purposes. The study reports do not include enough information to calculate these estimates precisely; therefore, they are roughly calculated using the reported mean marginal implicit price of pollution. Since the marginal implicit price usually increases as pollution increases, the actual property value differences attributable to pollution are understated in the higher pollution ranges.

per one pphm of NO_2. This implies an average property value difference of approximately $5,700 between homes in poor and in fair air quality locations, and an average difference of approximately $5,300 between homes in fair and in good air quality locations, all other things being equal. Average benefits for a regionwide 30% improvement in air quality were estimated to be between $44 and $49 per month per household. Aggregated across all households in the region, this amounted to annual benefits of $610 to $650 million for improvements from poor to fair air quality and annual benefits of $340 to $360 million for improvements from fair to good air quality. These results are similar, but not equivalent, to those of the bidding method study for the same communities. Given the difficulties in both procedures this is an encouraging result that supports the validity and defensibility of the benefit measures.

The San Francisco Bay Area (1980) study attempted to duplicate the South Coast Air Basin study in order to test the comparability of the results, but it was found that the study procedures had to be adapted to the different study area characteristics. The results of the two studies are similar, but they do indicate that results cannot necessarily be easily or directly transferred from one study area to the next. The final results of this study were based on measures of ozone and the PSI (Pollution Standards Index) that included both concentration levels and frequency of high level concentration occurrences. Although such measures make sense, they are difficult to interpret. The average annual benefits derived from the estimated WTP function were $82 per household for a 30% improvement in the ozone measure. Extrapolated to the entire study area, this amounted to about $136 million per year.

6.0 FUTURE DIRECTIONS FOR VISIBILITY BENEFIT ANALYSIS

Results of visibility benefit analyses conducted to date have shown that visibility benefits can be quantified, that the amounts are substantial enough to significantly influence benefit-cost analyses of air pollution controls, and that they improve the information available for resource allocation decisions. Nevertheless, much still needs to be done. Problems in these applications do exist. Complete confidence cannot as yet be placed in the exact values so far estimated, but progress is being made in the application of these techniques which warrants continued efforts in this area. First, the public and the public policy decision makers need to be made aware that the benefits of protecting visual aesthetics, just as the costs, are important and can be measured. Second, continued verification and refinement of the estimation techniques are needed in order to improve the reliability and credibility of the results.

The bidding methods need verification through more comparisons to actual market results and through follow-up studies to determine if actual behavior is consistent with predicted behavior. The most important question concerning the bidding methods is whether hypothetical markets can be used to derive accurate measures of visibility benefits. If it is determined that they can, the other application problems, such as implied property rights, detection of false bids, payment vehicles, and selection of WTP or WTA measures can probably be resolved.

Hedonic property value studies have some theoretical problems that need to be resolved. Most important is the question concerning the relationship between property value differentials and households' WTP, and whether reliable WTP functions can be identified from the information

provided by a cross sectional study of a single housing market. Another area that must be explored before property value studies can produce visibility benefit estimates is the identification of measures of aesthetic impacts that can be separated from measures of health impacts of air pollution.

More research is needed to determine the applicability of contingent travel cost, household production function, wage and salary, and ranked attribute approaches for visibility benefit analysis. It may be that some of these can be applied in situations when other techniques cannot be used. Some of these techniques have been quite successfully applied to other types of recreation demand questions.

Finally, more visibility benefit analyses need to be completed in order that there be a sufficient set of results from which to choose for transferring results to new study questions. This will allow estimates of visibility benefits to be obtained, in many cases, more quickly and inexpensively than by performing a complete visibility benefit analysis.